Operations Concepts Enabled by Cooperating Internet Spacecraft

Space Internet Workshop

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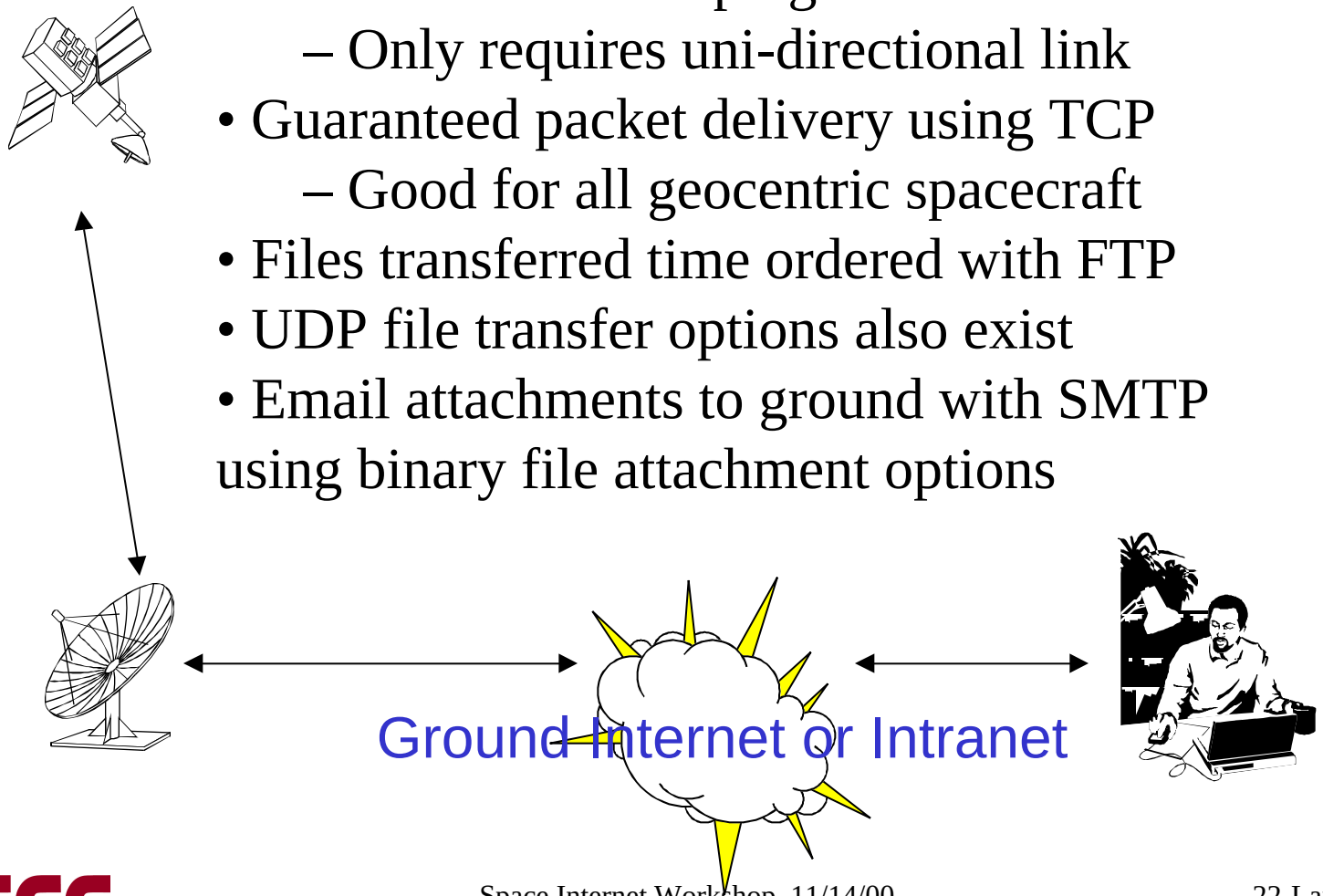
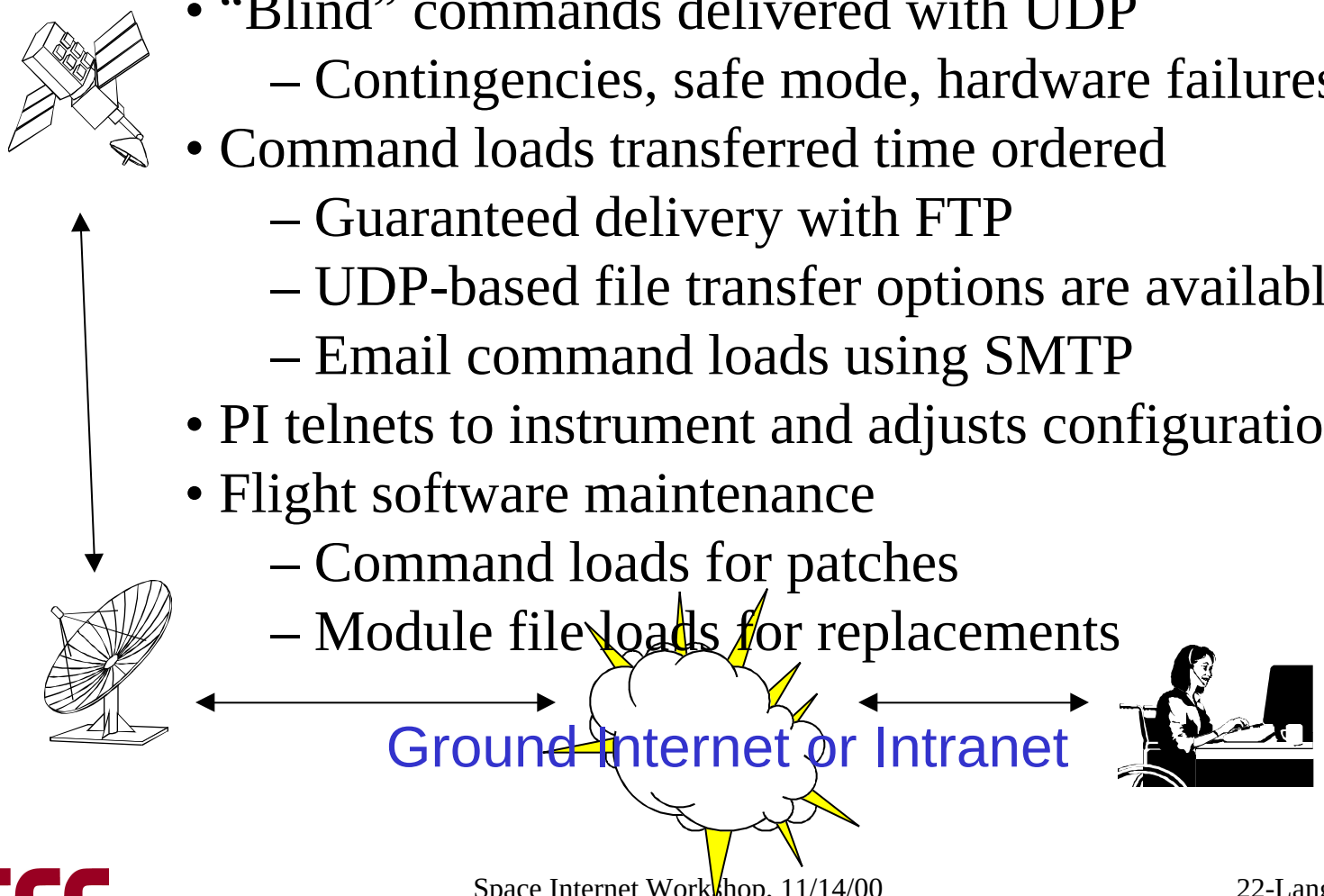
IP-Based Data Delivery

- Real-time housekeeping delivered with UDP
  - Only requires uni-directional link
- Guaranteed packet delivery using TCP
  - Good for all geocentric spacecraft
- Files transferred time ordered with FTP
- UDP file transfer options also exist
- Email attachments to ground with SMTP using binary file attachment options

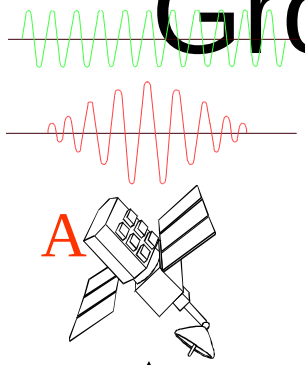


IP-Based Commanding

- Guaranteed real-time command delivery using TCP
- "Blind" commands delivered with UDP
  - Contingencies, safe mode, hardware failures
- Command loads transferred time ordered
  - Guaranteed delivery with FTP
  - UDP-based file transfer options are available
  - Email command loads using SMTP
- PI telnets to instrument and adjusts configuration
- Flight software maintenance
  - Command loads for patches
  - Module file loads for replacements

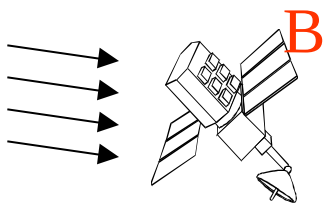


Ground-Based Cooperation

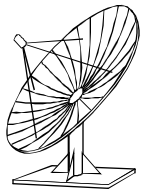


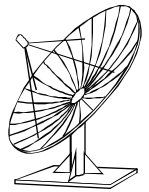
Detects Event

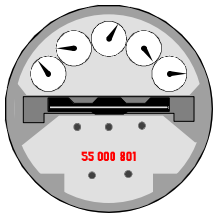
- Spacecraft A detects solar flare and sends messages
  - IP address list configured on orbit
- Power grid systems automatically adjust to protect against power surge
- Alarm messages received by operators
- Spacecraft B automatically maneuvers to target this event
- Requires spacecraft ground contact



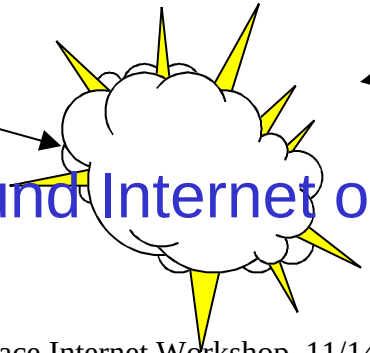
Targets Event







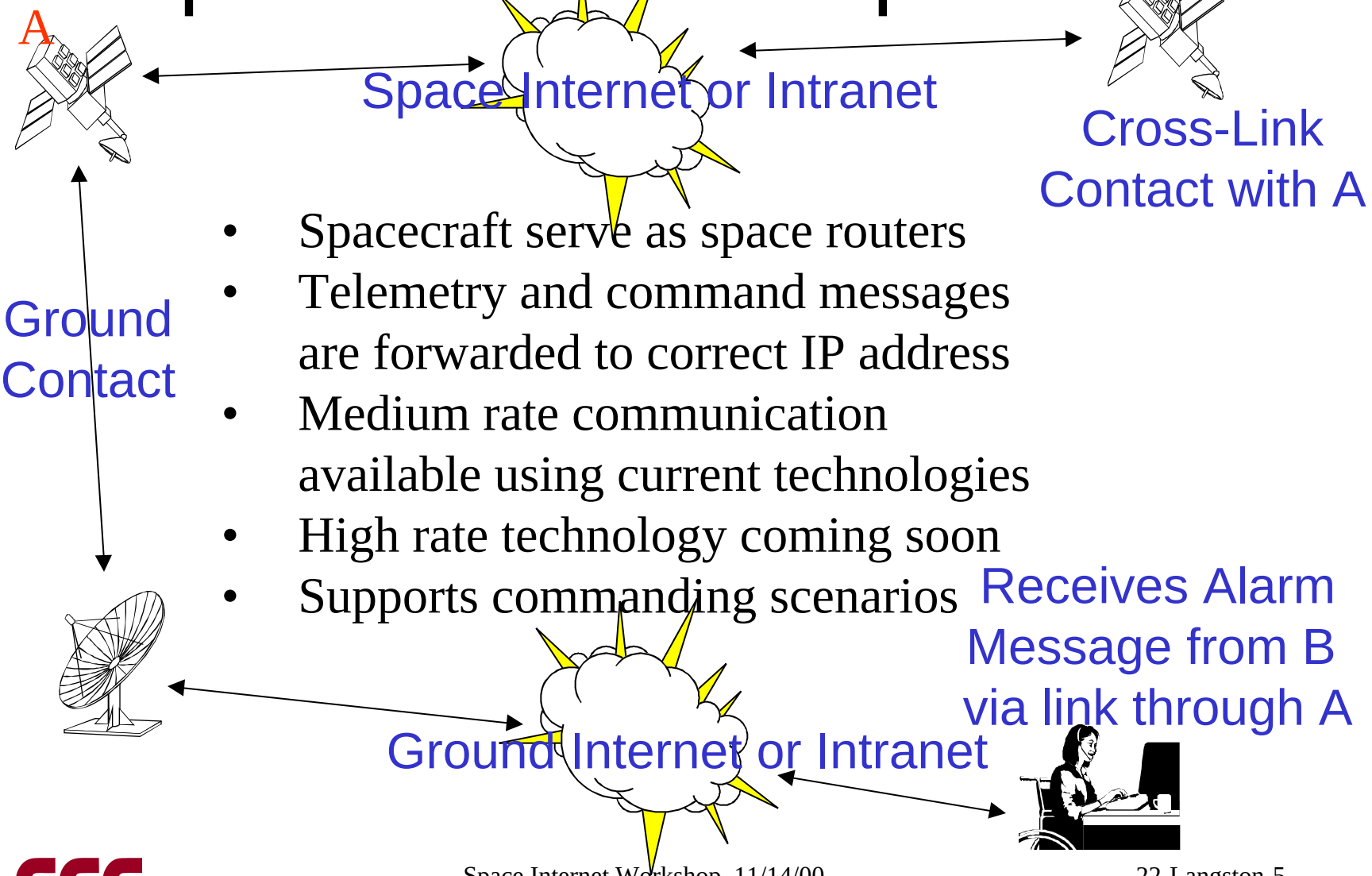
Power Grid



Ground Internet or Intranet

Alarm Message

Space-Based Cooperation

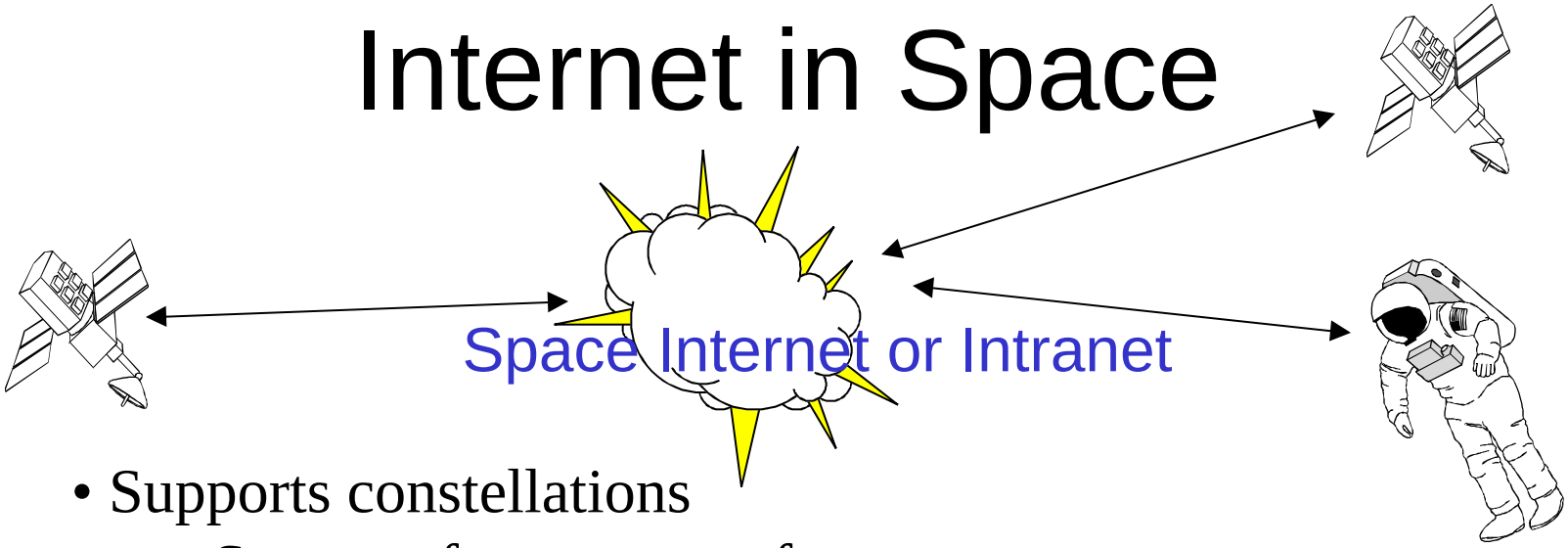


- Spacecraft serve as space routers
- Telemetry and command messages are forwarded to correct IP address
- Medium rate communication available using current technologies
- High rate technology coming soon
- Supports commanding scenarios

Standard Cross-Link Capability

- Design a standards-compliant cross-link capability
  - Ensure Low cost, low power, low weight
  - Use emerging COTS technologies (e.g., mobile phones, blue tooth, wireless Ethernet)
  - Available today for lower cross-link rates
- Cooperating spacecraft receive packets and forward them to neighboring spacecraft as broadcast
  - Duplicates are discarded to damp out thrashing
- Benefit is ground can communicate with spacecraft on demand by sending to target IP address and messages will go up via whatever spacecraft is currently in contact
  - Can lead to lower operational costs

Internet in Space



- Supports constellations
  - Spacecraft to spacecraft
  - Through a common relay spacecraft to ground
- Supports cooperating missions reconfigured on orbit
  - Destination by IP address easily reconfigured
- Supports inter-planetary missions with UDP options
  - Mars Sat could serve as relay with Earth or Moon
- Supports human spaceflight